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Fisheries Assistance Office
Olympia, Washington

ESCAPEMENT ESTIMATION OF THE 1978-79 AND 1979-80 NOOKSACK RIVER CHUM SALMON RUNS

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INTRODUCTION

From 1976 to 1980 the Nooksack and Lummi Indian Tribes and the Olympia Fisheries Assistance Office of the U.S. Fish and Wildlife Service (USFWS), with cooperation from the Washington Department of Fisheries (WDF), conducted tagging studies to estimate escapement of chum salmon (Oncorhynchus keta) on the Nooksack River. This run is important for the terminal area treaty and non-treaty fisheries and river fisheries of the Nooksack and Lummi Tribes. Accurate information on escapement is essential for proper management because the river currently supports a viable natural run.

The WDF has based Nooksack chum escapement estimates on index area live and dead counts, assuming that the current year's index count is the same proportion of the escapement as in the base year, 1968, when a mark-and-recapture study was done for all of Puget Sound (Mathews and Johnson 1969).

Redocumentation of a base year escapement estimate was deemed important for two reasons. First, the 1968 study, because it attempted to estimate escapement throughout Puget Sound, probably did not estimate escapement to individual watersheds with great accuracy. Second, the patterns of distribution within the watershed and particularly in the index areas probably changed over time thus requiring intermittent base year escapement reevaluation.

The objectives of this study were

(1) to estimate the run size entering the river and the escapement to the spawning grounds; and

(2) to determine the biological characteristics of the run, including sex ratio, length frequency, age composition, and timing and distribution of spawning.

This report describes the 1978-79 and 1979-80 runs. The 1978-79 escapement has been reported previously (Nooksack Tribe et al. 1979).

The first two years of mark-recapture attempts resulted in little success. Tagging with a purse seiner in 1976 gave few usable returns because of prohibitive costs and inaccurate commercial recovery data. Drift gillnetting in 1977 successfully captured fish for tagging, but the lower river fishery intercepted many fish and thus biased the run size and escapement estimates. Also, spawning ground surveys yielded few recoveries (Lummi Tribe et al. 1978).

STUDY AREA

The Nooksack is a large river of glacial origin which enters Bellingham Bay several miles north of Bellingham Washington (Figure 1). Substantial runs of chum salmon, steelhead trout (Salmo gairdneri), pink salmon (O. gorbuscha), coho (O. kisutch), and fall chinook (O. tshawtscha) use the system along with smaller stocks of spring chinook salmon, cutthroat trout (S. clarki) and dolly varden char (Salvelinus malma). Agriculture and food processing are the major activities on the lower watershed; logging and mining are important in the upper watershed.

The treaty commercial fishery for Nooksack River chum is conducted in WDF Catch Reporting Area 7B and in the Nooksack River up to River Mile 37. There is significant marine interception.

Drift gillnets are the most common gear in the lower river, although tidal action occasionally permits use of setnets. Although chum are the most numerous species in November, steelhead are also taken commercially beginning in December.

METHODS

The tagging technique generally followed that of the 1977-78 study (Lummi Tribe et al. 1978). The fish were captured for tagging during daylight hours at various sites in the lower river (Figure 2). The tribal fishermen would set a drift gillnet (15cm (6 inch) stretch measure multifilament). A second boat drifted downstream behind the net, removing fish as soon as they struck, which was usually indicated by the bobbing corkline. Captured fish were placed in a live pen in the boat and the drift was continued. At the end of the set the fish were taken to a tagging cradle on shore.

In 1979 a few fish were also captured at night by drift gillnet below RM 1.4 and by set gillnet at RM 5. Each chum was tagged with a metal butt-end tag[1] clamped around its mandible.

The fish's length and sex were recorded and the adipose fin was clipped to allow for identification of fish that had shed tags before recovery. The fish was placed in a holding pen for a short period to observe its condition and prevent recapture in the next set. We assessed the fish's condition as:

1 = swam into pen quickly
2 = swam into pen slowly, or
3 = disoriented.

In addition, a maturity factor of

1 = bright
2 = intermediate, or
3 = dark

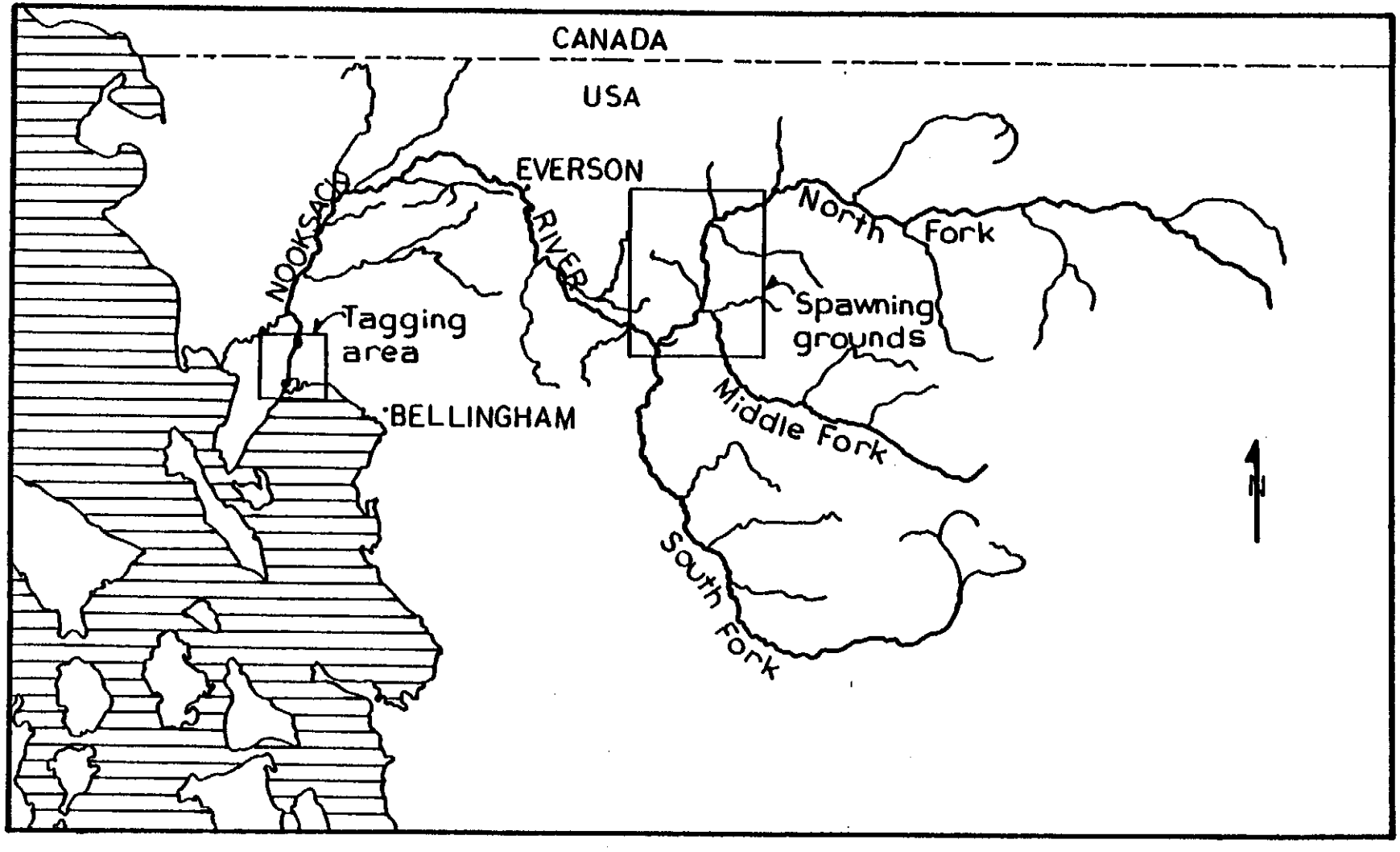

Figure 1. The Nooksack River watershed showing the tagging locations and spawning grounds of chum salmon, 1978-79 and 1979-80.

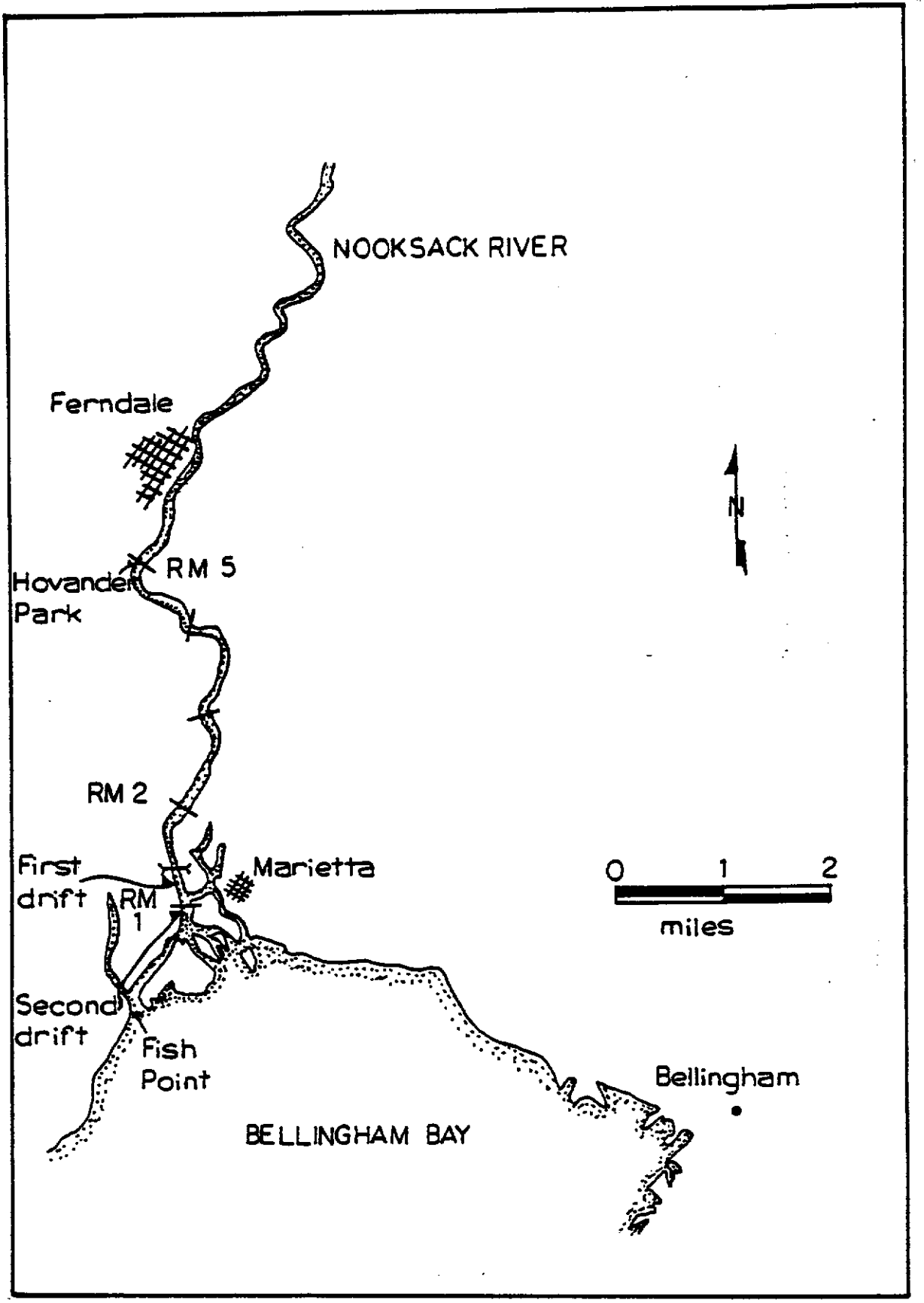

Figure 2. Tagging sites, 1979, lower Nooksack River.

was recorded. After short-term holding to monitor condition, the fish were released upstream of the capture site or at the capture site if tagging was completed for the day. Efforts were made to prevent interception of tagged fish and facilitate a direct estimate of escapement above the river fishery. Tagging was generally not conducted on days just before or during commercial fishery periods. When actual or near concurrency was unavoidable, the fish were released above the Marietta Bridge to avoid the fishing area. The river catch was mark-sampled to confirm the absence of interception.

Carcasses were sampled weekly on the spawning grounds (Figure 3) for tag recovery. All chum carcasses were examined for adipose clips and jaw tags were counted as part of the sample if the adipose clip was detectable. The tail was cut off all carcasses to prevent duplicate counts. In 1978-79 every carcass was measured and sexed. In 1979-80 scales, sex, and fork length were taken from a random sample of carcasses. Additional data was obtained from egg-taking operations of the Nooksack Tribe at Rutsatz Slough and from the activities of WDF at the Kendal Creek Hatchery.

The Petersen Method (Seber 1973) was chosen as the method for calculating the size of population entering the river following consideration of the required assumptions. It can be written as:

$$\hat{N} = \frac{n_1 \, n_2}{m}$$

where n_1 = number of tags released

n_2 = number of carcasses examined on the spawning grounds and at broodstock capture

m = number of adipose-clipped carcasses recovered

The standard deviation as derived from Seber (1973:60) is

$$S = \hat{N}\sqrt{(1/m)+(2/m^2)+(6/m^3)}$$

The escapement equals the estimated population less commercial catch, ceremonial and subsistence catch, and broodstock capture.

VALIDITY OF ASSUMPTIONS

The Petersen model requires several assumptions (Youngs and Robson 1978):

(1) the population is closed to recruitment and immigration-Seber (1973) requires closure to emigration as well;

(2) marked fish have the same mortality and behavior to gear as unmarked fish;

(3) marked fish do not lose their mark;

(4) all marked fish are reported on recapture; and

(5) either the marking or recapture sample is random, or there is random mixing of marked and unmarked fish.

If only Assumptions (1) through (4) are valid, the population can still be estimated, but the Darroch (1961) stratified model instead of the Petersen must be used. The Darroch model divides the marking and recovery samples into strata so that all fish have the same probability of being caught in each marking stratum, and the same probability of being recaptured in each recovery stratum.

Assumption 1

Closure implies that all fish must be available for recapture. This means they must neither die before reaching a recovery location nor stray from the Nooksack system to spawn elsewhere. Prespawn mortality was probably insignificant because chum were tagged only a short time before spawning.

Straying was also probably insignificant. No tags were voluntarily returned from outside the Nooksack system in 1978-79, although 9 were voluntarily returned from within the system. One tag was returned with no information on recovery location in 1979-80, but five others came from within the system.

Assumption 2

Marking did not affect recoverability on spawning grounds because technicians were trained to exaimine all carcasses without bias. No fishery occurred in 1978, but there was a commercial gillnet fishery on the river in November 1979. It is also unlikely that marking increased catchability in the fishery. No marks were recovered in a sample of 153 fish, or 31% of the catch, taken between November 2 and 19.

Further, it is not likely that marking caused mortality before fish reached recovery areas. If this were so, we would expect successively lower recovery rates in those classes of fish judged to be in successively poorer condition after marking. To test for this, a chi-square test of condition at release by recovery rate was performed (Table 1). The non-significance of the results supports the assumption of negligible marking mortality.

Assumption 3

No marks were lost before recovery, because clipped adipose fins were not regenerated in the short period before recovery.

Table 1. Chi-squared analysis of chum recovery rates by condition at release after tagging.

Year				X^2	df	P
	Cond. 1	Cond. 2	Cond. 3			
1978-79	0.32	0.40	0.22	2.110	2	> 0.1
1978-79	0.13	0.14	0.28	2.120	2	> 0.1

Assumption 4

All marked fish were recognized as such, because technicians were trained to look primarily for the adipose clip.

Assumption 5

Marking and recapture were designed to take a random sample over time, area, sex, and length. To evaluate possible discrepancies, the tagging and recapture populations were tested for stratification using Seber's (1973) techniques. The population was first tested by chi-square analysis to see if all fish had the same chance of being caught for marking. The tag ratio was tested against data, then location of recovery. (The tag ratio is the number of marked fish recovered per number examined). Non-significance would establish randomness of the marking catch.

Next, the population was tested to see if recovery was a random sample. The recovery rate was tested against date, location, fish length, and sex at tagging. (Recovery rate is the number of marked fish recovered per number released.) Non-significance would establish randomness of the recovery sample.

Tests validated this assumption. In 1978-79 tagging was random even though recovery favored chum tagged in the middle of the run (Table 2, Appendix Tables 1-6). In 1979-80 recovery was random even though tagging operations favored chum entering at the beginning and middle of the run (Table 3, Appendix Tables 7-12).

POPULATION ESTIMATES

1978-79

We tagged 253 chum in 25 days of tagging between November 2 and December 27,1978 (Table 4). In addition, 127 coho and 66 steelhead were captured. We examined 3,900 carcasses in 37 days of spawner survey between November 27 and January 26 and recovered 100 marked fish (Table 5). Nine tags were recovered out of sample, all from the Nooksack system. An estimated 9,867 fish entered the river and 8,852 escaped to spawn (Table 6). Although stream conditions apparently made recovery effort more effective during the middle of the run, uniform tagging allowed an unbiased population estimate. This was slightly over the then-current escapement goal set by WDF.

The population estimate is slightly different from that reported earlier (Nooksack Tribe et al. 1979) because we made a single estimate combining both sexes and the broodstock capture was larger than first reported.

Table 2. Results of Chi-Square analysis in examining assumptions of Petersen population estimate, 1978-79.

Test	X^2	df	P
Recovery rate by tag date	9.138	3	< 0.05
Recovery rate by tag location	1.193	1	> 0.1
Recovery rate by tag length	3.486	3	> 0.1
Recovery rate by tag sex	0.918	1	> 0.1
Tag ratio by recovery date	13.637	8	> 0.05
Tag ratio by recovery location	5.182	10	> 0.5

Table 3. Results of Chi-Square analysis in examining assumptions of Petersen population estimate, 1979-80.

Test	X^2	df	P
Recovery rate by tag date	14.198	9	> 0.1
Recovery rate by tag location	3.952	4	> 0.1
Recovery rate by length	7.994	4	> 0.05
Recovery rate by sex	0.050	1	> 0.5
Tag ratio by recovery date	25.689	6	< 0.005
Tag ratio by recovery location	11.489	8	> 0.1

Table 4. Gillnet catch during tagging, 1978.

Date	Chum captured	Chum tagged	Coho	Steelhead
11/2	18	18	1	0
11/3	0	0	4	0
11/9	4	5[a]	11	0
11/10	12	12	24	0
11/11	10	10	14	2
11/12	4	3	11	0
11/15	1	1	2	0
11/16	36	36	5	0
11/17	6	6	14	1
11/22	0	0	2	0
11/24	2	2	1	1
11/27	3	3	0	1
11/28	0	0	0	1
11/30	66	66	3	3
12/1	2	2	5	0
12/2	3	3	4	8
12/4	25	25	4	3
12/5	3	3	3	1
12/6	0	0	4	8
12/9	14	17[b]	1	1
12/14	13	13	5	12
12/16	21	21	4	13
12/19	3	3	4	2
12/20	5	4	0	8
	1	0	1	1
Total	252	253	127	66

a. Additional fish retrieved from discarded net near shore.

b. Additional fish confiscated from illegal fishing activity.

Table 5. Distribution of chum carcasses on spawning grounds.

Location	1978-79 Total	1978-79 Marked	1979-80 Total	1979-80 Marked
Mainstem North Fork from Boulder Creek to Kendal Creek	365	8	2	0
Slough[a] at RM 52	15	0	3	0
Side channel[b] above Maple Creek	c	c	11	0
Maple Creek	416[g]	12	742[g]	8
Tributary 0411 and Slough	322	8	36	2
Slough above Wick's Slough	311	7	d	d
Wick's Slough, Kendal Creek and associated sloughs and side channel, mainstem North Fork at Kendal Hatchery, and Bear Creek and associated slough (1978-79) or side channel (1979-80)[e]	1143[h]	26	1685[h]	26
Slough below Wick's Slough	8	0	d	d
Mainstem North Fork just below Kendal Creek	2	0	c	c
Mainstem North Fork from Kendal Creek to Mosquito Lake Road Bridge	549	10	120	7
Coal Creek	c	c	26	0
Johnny's Slough	f	f	270[g]	5
Slough below Racehorse Slough	d	d	17	0
Side channel 1 mi. above Mosquito Lake Road Bridge	c	c	45	0
Side channel just above Mosquito Lake Road Bridge	c	c	599[g]	11
Slough just above Mosquito Lake Road Bridge	c	c	74	3
Slough opposite Bell's Creek	68[g]	3	15[g]	0
Side channel at natural gas pipeline crossing	150	5	131	1
Rutsatz Slough	551	21	551	8
Irving's Slough (Mainstem RM 22)	c	c	24	0
Total	3900	100	4351	71

a. Defined here as a channel in the floodplain, flowing into the mainstem from either a tributary or a spring.
b. Defined here as a channel in the floodplain, fed entirely by it.
c. Not surveyed.
d. Not present both years due to riverbed change.
e. See Appendix Table 13 for details.
f. Fish passage blocked by beaver dam.
g. WDF index area.
h. Includes WDF index area. See Appendix Table 13 for details.

Table 6. Mark-recapture information and population characteristics of the 1978-79 run.

Mark-recapture Information	
Tagged	253
Sampled	3,900
Tags recovered in sample	
Broodstock	10
Spawner survey	90
Total	100
Population Characteristics	
Run size	9,867
Standard deviation	1,000
Catch	
Commercial	570[a]
Ceremonial and subsistence	114[a]
Nooksack broodstock capture	331
Total	1,015
Escapement	8,852
Escapement goal	7,600[b]

a. Paul Hage, Nooksack Tribal Biologist, personal communication.
b. WDF 1978

1979-80

We tagged 432 chum in 22 days of tagging between November 1 and December 11, 1979 (Table 7). In addition, 101 coho and 7 steelhead were captured.

The commercial fishery did not appear to intercept any tags, as shown by a sample of 153 fish taken from November 2 to 19. We examined 4,363 carcasses in 24 days of spawner survey between November 26 and January 25 and recovered 71 marked fish (Table 5). Six tags were recovered out of sample. Five were from the Nooksack system but no information accompanied the sixth tag. We assumed that no fish strayed from the Nooksack system because no tags were definitely recovered out of system. An estimated 27,776 fish entered the river and 27,297 escaped to spawn (Table 8). This was well above the goal established by WDF. Although flooding prevented tagging during the last part of the run, uniform recovery rates allowed an unbiased population estimate.

BIOLOGICAL CHARACTERISTICS

Sex Ratio

Males outnumbered females in the tagging catch both years, but females became more abundant than males after the peak of the run (Tables 9,10). However, the sex ratio at tagging does not represent that of the population entering the river because the males had a significantly higher tag ratio than females both years (Table 11).

Females outnumbered males in the spawning ground survey both years. There is evidence both for and against this ratio representing the escapement.

The fact that males and females had essentally equal recovery rates (Table 12) suggests that both sexes were equally available to recovery so that survey should give an unbiased sex ratio.

On the other hand, there is evidence that females were more accessible to survey than males. The male-female carcass ratio was significantly higher on the mainstem than the tributaries (Table 13), which suggests that males left the tributaries before dying but females tended not to do so. The main stem sex counts cannot be added to tributary counts to give an overall sex ratio because visibility is less in the main stem. Therefore, the observed sex ratio is not necessarily representative of the escapement.

Length Frequencies

Males were consistently larger than females in the lower river catch (Table 14). Carcasses were larger than fish captured in the lower river, but the difference was not great. In 1979-80 females on spawning grounds were somewhat larger than in 1978-79. No explanation was apparent.

Table 7. Gillnet catch during tagging, 1979.

Date	Time	Method	Chum		Coho	Steelhead
			Captured	Tagged		
11/1	day	drift	2	2	38	0
11/2	"	"	1	1	25	0
11/8	"	"	0	0	7	0
11/9	"	"	1	1	7	0
11/14	"	"	0	0	3	0
11/15	"	"	3	3	3	0
11/16	"	"	0	0	1	0
11/16	night	set	3	3	0	0
11/19	day	drift	28	27	3	0
11/19	night	set	4	4	0	0
11/20	day	drift	0	0	0	0
11/21	night	set	6	6	0	0
11/25	"	"	12	12	0	0
11/26	day	drift	4	4	2	0
11/27	"	"	1	1	1	0
11/30	"	"	33	32	0	2
12/1	"	"	11	11	1	0
12/1	night	"	21	21	1	1
12/2	day	"	73	70	0	1
12/3	"	"	80	80	3	1
12/5	"	"	110	93	2	0
12/6	"	"	10	10	0	0
12/6	night	"	32	32	1	0
12/10	day	"	17	17	0	0
12/11	"	"	27	27	3	2
Total			479	457	101	7

Table 8. Mark-recapture information and population characteristics of the 1979-80 run.

Mark-recapture information	
Tagged	457
Sampled	4,361
Tags recovered in sample	
Broodstock	3
Spawner survey	68
Total	71
Population Characteristics	
Run size	28,070
Standard Deviation	3,380
Catch	
Commercial	489
Broodstock	202
Total	691
Escapement	27,379
Escapement Goal[a]	17,500

a. WDF 1979

Table 9. Sex ratio by tag date, 1978.

Dates	N	% M	% F
11/2 to 11/27	96	60.4	39.6
11/30 to 12/5	99	56.6	43.4
12/9 to 12/20	58	36.2	63.8
Combined	253	53.4	46.6

Table 10. Sex ratio by tag date, 1979

Dates	N	% M	% F
11/1 to 11/27	64	68.8	31.3
11/30 to 12/5	307	56.7	43.3
12/6 to 12/11	86	44.2	55.8
Combined	457	55.8	44.2

Table 11. Chi-squared analysis of tag ratio by sex.

Year	Sex	m	n_2	X^2	df	P
1978-79[a]	M	1649	51			
	F	2217	35	9.625	1	< 0.005
1978-80	M	1744	37			
	F	2619	34	4.390	1	< 0.05

a. 34 fish not sexed.

Table 12. Chi-Squared analysis of recovery rate by sex.

Year	Sex	m	n_1	X^2	df	P
1978-79	M	135	51			
	F	118	35	1.395	1	> 0.1
1979-80	M	237	31			
	F	195	25	0.101	1	> 0.5

Table 13. Chi-squared analysis of sex ratio by location 1978, including some fish not counted in populations estimate. Not all locations included.

Sex	Tributaries	Main stem
M	637	1029
F	687	1303

$X^2 = 5.41$ df = 1 $P < 0.025$

Table 14. Length(cm) by location and sex, 1978-79 and 1979-80. Sample size in parenthesis includes some fish not counted in population estimate in 1978-79.

	M	F
1978-79		
Tagging	78.6 (135)	72.6 (118)
Recovery	80.0 (1685)	73.8 (2254)
1979-80		
Tagging	77.0 (254)	73.3 (201)
Recovery	80.6 (112)	75.7 (176)

Age Composition

Nooksack chum were predominantly age IV in 1979-80. Age composition was about the same throughout the run (Table 15) and among the various recovery areas (Table 16), although extensive combining of mainstem and tributary sites was needed to give sample size adequate for comparison. Both sexes had about the same age composition (Table 17).

Timing, Distribution, and Spawning Density

The catch per unit tagging effort indicates that most of the run entered the river before December 19 in 1978 (Figure 4) and after November 16 in 1979 (Figure 5). Highest catch per effort in 1978 was on November 30 and on December 5 in 1979. Some chum could have entered the river before tagging began in 1978, but few had entered until early December in 1979. The run was essentially over by December 27 in 1978, but flooding prevented determination of the end of the run in 1979. The delayed entry in 1979 was probably due to unusually low, clear water that kept most fish from moving until the first week in December.

Almost all spawning occurred on the North Fork and its tributaries between RM 36.0 and 51.7. However, spawning was also observed at RM 26 on the mainstem. Tributary spawning ranged from Bell's Creek to Maple Creek. No fish were observed in the Middle Fork during one survey early in 1978 and only two carcasses were seen in the South Fork in two surveys during the 1978-79 run.

Live counts per mile of tributaries indicate that most of the run was on the spawning grounds between November 20 and January 20 (Figure 6).

Different parts of the system had different spawning times. This suggests the existence of partially separate populations. In 1978-79 tributary 0411 and Bear Creek peaked earliest, and were followed by Rutsatz Slough, Bear Creek Slough, and Bell's Creek Slough. Last in sequence were Maple Creek and the Pipeline side channel. In 1979-80 as in 1978-79, Bear Creek Slough peaked earlier than Maple Creek or Pipeline.

Peak counts in 1979-80 seemed to occur about two weeks later than in 1978-79, probably because a relatively dry period delayed peak entry into the river in 1979 by about a week; and because later, severe flooding somehow either delayed spawning activity or delayed our ability to identify peak activity. In any case, peak spawning at Maple Creek and Pipeline could have occurred somewhat earlier than we observed because the flooding kept us away from these areas for almost two weeks.

Distribution on the spawning grounds differed somewhat between the two years. In 1979 several new heavily-used spawning grounds were discovered, including Johnny's Slough and the slough and side channel upstream from the Mosquito Lake Road Bridge (Figure 3).

Table 15. Age composition by recovery date, 1979-80.

Date	N	% III	% IV	% V
12/11 to 1/2	103	11.7	82.7	5.8
1/4 to 1/8	103	10.7	85.4	3.9
1/10 to 1/17	87	5.7	89.7	4.6
Combined	293	8.3	86.8	4.9

Table 16. Age composition versus recovery location 1979-80.

Location	N	% III	% IV	% V
Maple Creek	48	12.5	81.3	6.3
Upper Mainstem[a]	69	14.5	82.6	2.9
Kendal Creek and Slough	40	7.5	87.5	5.0
Bear Creek System[b]	79	5.1	88.6	6.3
Lower Mainstem[c]	79	8.9	87.3	3.8

a. Consists of North Fork from Boulder Creek to Kendal Creek, slough at RM 52, Tributary 0411 and slough, and Wick's Slough.

b. Bear Creek Slough, Racehorse Slough, Johnny's Slough, and vicinity.

c. North Fork and associated sloughs and side channels from Kendal Creek to Mosquito Lake Road Bridge, side channel at Natural gas pipeline crossing, and Rutsatz Slough.

Table 17. Length composition(cm) by sex and age from carcass recovery (Sample size in parentheses)

Sex	Age		
	III	IV	V
M	70.4 (12)	81.3 (89)	83.3 (8)
F	70.7 (16)	75.9 (163)	75.5 (4)

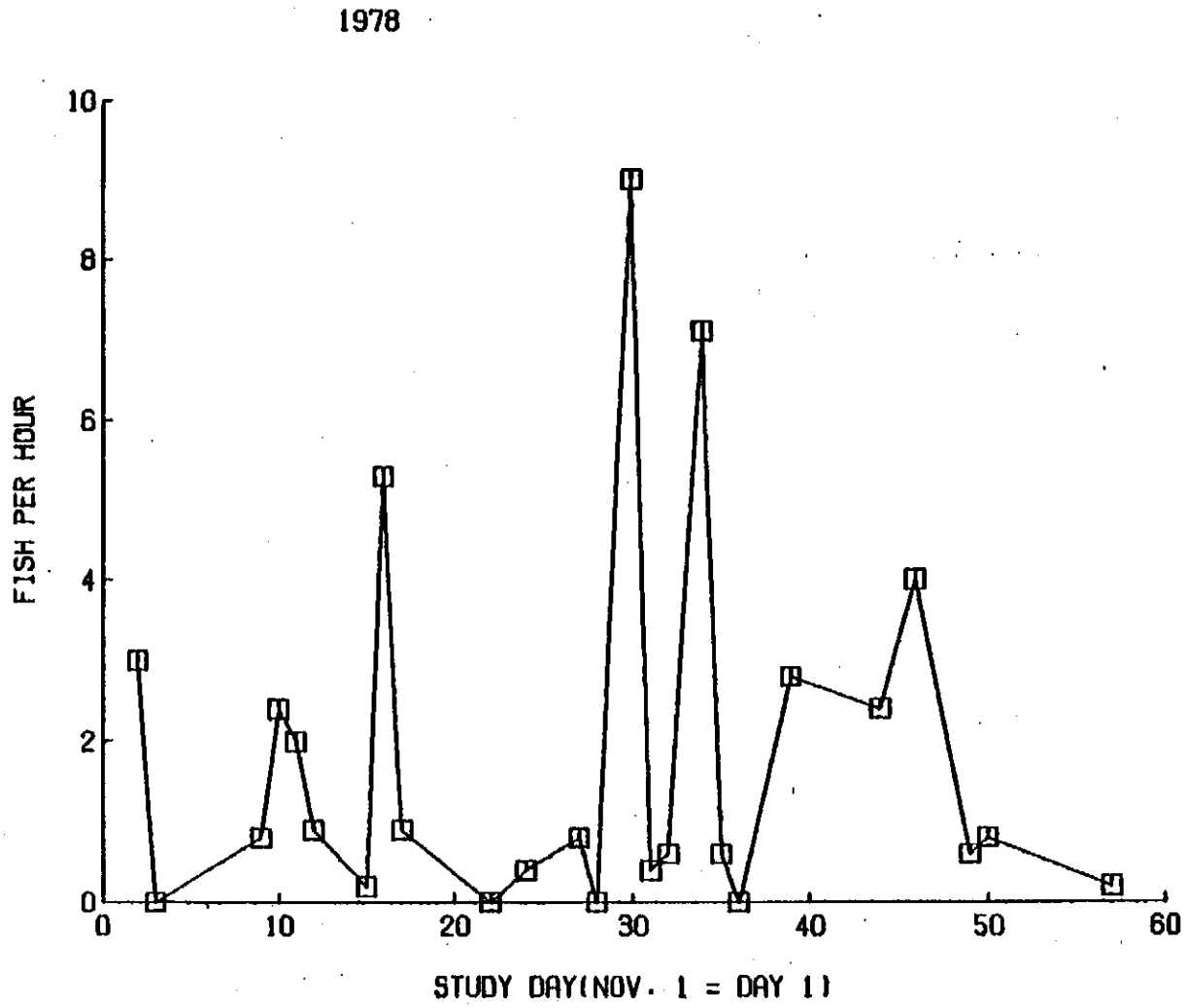

Figure 4. Chum catch by drift gillnet in 1978 tagging, lower Nooksack.

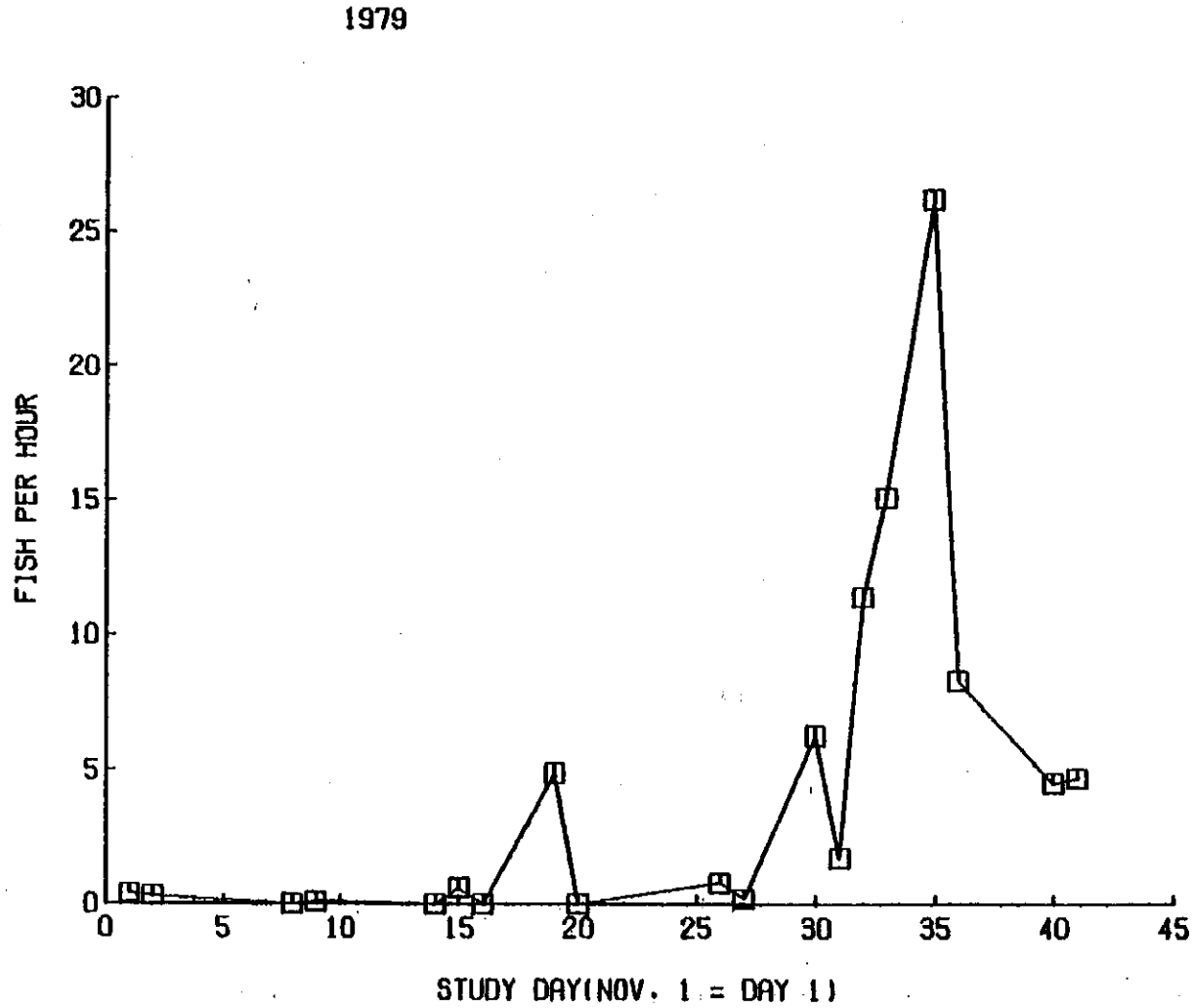

Figure 5. Chum catch by drift gillnet in 1979 tagging, lower Nooksack river.

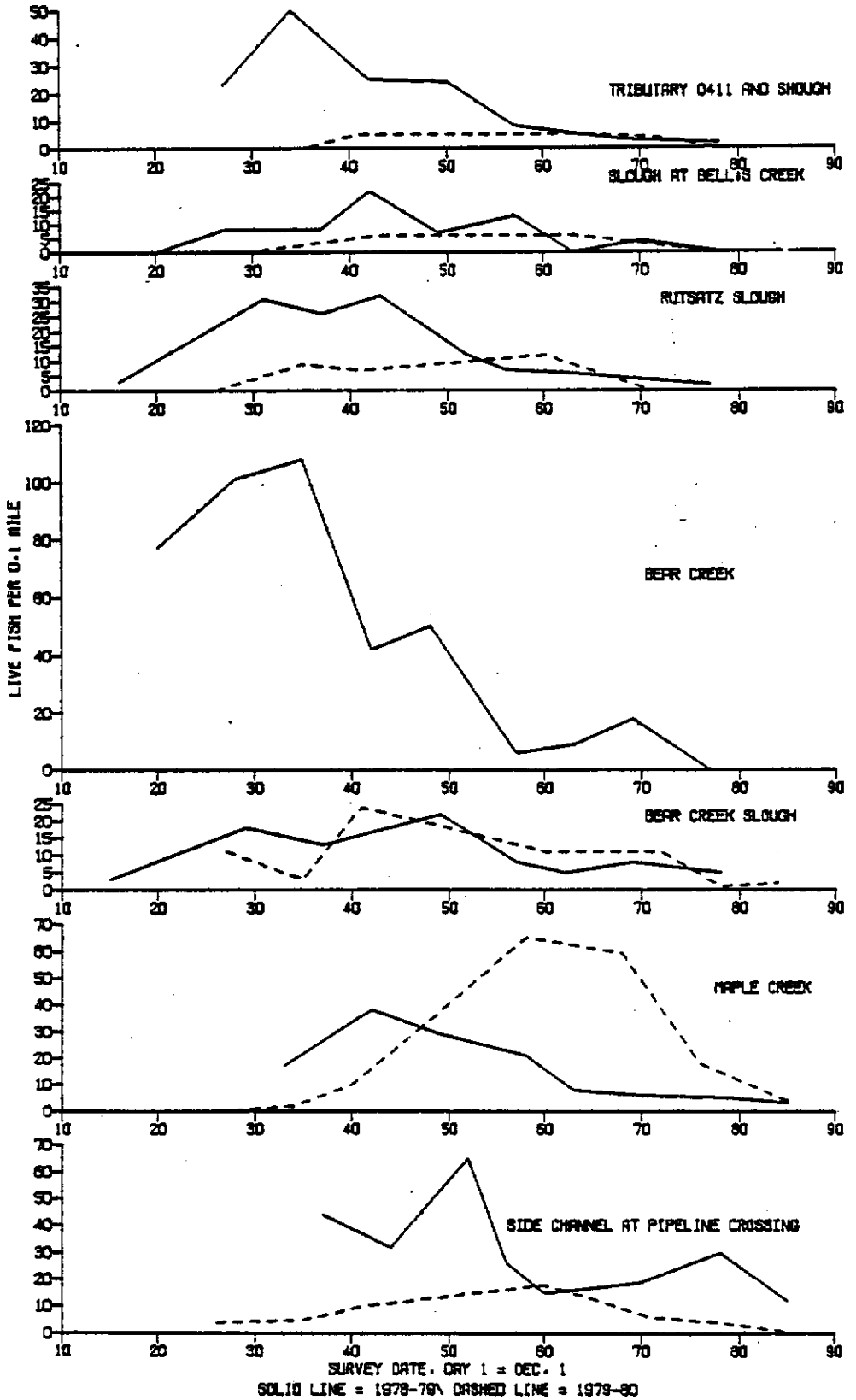

Figure 6. Chum timing and distribution on selected spawning grounds, North Fork Nooksack River.

The main stem North Fork, especially from Maple creek to Kendal Creek, was a far more productive area for carcass recovery in 1978-79 than 1979-80 (Table 5). Severe flooding in late 1979, may have washed out most of the carcasses from this area before they could be observed.

The observed peak spawning density differed among the tributaries and between years (Figure 6). In 1978-79 highest density was at Bear Creek and the lowest at Bear Creek and Bell's Creek Slough. In 1979-80 Maple Creek was the most heavily used of the tributaries surveyed while Tributary 0411 and Bell's Creek Slough appeared to receive the least density of spawners. Bear Creek was not consistently surveyed in 1979-80 so no information on spawning density was available.

Fish appeared to take more time to reach upper tributaries than lower ones. Time elapsed from tagging to recovery, correlated significantly with river mile at entry of the tributary (Table 18).

Table 18. Time from tagging to individual carcass recovery on major spawning tributaries.

Tributary	River mile	Days elapsed to recovery (N Parenthesis) 1978-79	1979-80
Rutsatz Slough	36.7	22 (13)	25 (7)
Bear Creek	45.1	32 (10)	27 (8)
Kendal Creek	45.8	-	31 (8)
411	48.4	32 (8)	-
Maple Creek	49.7	37 (12)	33 (7)
		$r = 0.997$ $P < 0.01$	$r = 0.999$ $P < 0.01$

SUMMARY

1. The 1978-79 Nooksack chum run size was estimated to be 9,867 fish, and the escapement was 8,852.

2. The 1979-80 run size was 27,776 and the escapement, 27,297.

3. Fish were mainly age IV in 1979-80.

4. Peak tagging catch per effort in 1978 was on November 30 and in 1979 on December 5.

5. Almost all spawning occurred on the North Fork Nooksack and its tributaries between River Miles 36 to 52.

LITERATURE CITED

Darroch, J. N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48 (3): 241-260.

Lummi and Nooksack Indian Tribes and USFWS, Fisheries Assistance Office, Olympia. 1978. The 1977-78 Nooksack River chum population study: preliminary report. July 1978. 6p.

Mathews, S. B. and R. C. Johnson. 1969 (?) Puget Sound chum salmon catches and escapement based on 1968 tagging. Washington Department of Fisheries. Unpublished manuscript. 14p.

Nooksack and Lummi Indian Tribes and USFWS, Fisheries Assistance Office, Olympia. 1979. Progress report: escapement estimation of the 1978-79 Nooksack River chum salmon run. 7p.

Seber, G. A. F. 1973. The estimation of animal abundance and related parameters. Griffin. London. 506p.

WDF. 1978. 1978 status of Puget Sound chum salmon and recommendations for management. Progress Report 71. 15p.

_____1979. 1979 status of Puget Sound chum salmon and recommendations for management. Progress Report 92. 23p.

Youngs, W. D. and D. S. Robson. 1978. Estimation of population number and mortality rates. Pp. 137-164 In T. Bagenal. Methods for assessment of fish production in fresh waters. Blackwell Scientific Publications. Oxford.

APPENDIX

Table 1. 1978-79 recovery rate by date of tagging.

Tagging dates	Number tagged	Number recovered
11/2 - 11/12/78	48	10
11/15 - 11/27	48	23
11/30 - 12/5	99	40
12/9 - 12/20	58	13

$X^2 = 9.138$ df = 3 $P < 0.05$

Table 2. 1978-79 recovery rate by location of tagging.

Tagging location	Number tagged	Number recovered
Second drift	231	81
others	22	5

$X^2 = 1.193$ df = 1 $P > 0.1$

Table 3. 1978-79 recovery rate by fish length at tagging.

Length (cm)	Number tagged	Number recovered
55-69	40	10
70-74	70	18
75-79	82	31
80-94	61	27

$X^2 = 3.486$ df = 3 $P > 0.01$

Table 4. 1978-79 recovery rate by sex at tagging.

Sex	Number tagged	Number recovered
M	135	51
F	118	35

$X^2 = 0.918$ df = 1 $P > 0.1$

Table 5. 1978-79 tag ratio by date of recovery.

Dates	Number recovered	Number marked
11/13 - 12/5/78	135	5
12/6 - 12/12	550	11
12/13 - 12/19	837	18
12/20 - 12/26	654	16
12/27 - 1/2/79	714	25
1/3 - 1/9	391	14
1/11 - 1/16	301	2
1/18 - 1/19	232	5
1/25 - 1/26	86	4

$X^2 = 13.637$ df = 8 $P > 0.05$

Table 6. 1978-79 tag ratio by location of recovery.

Location	Recovered	Marked
Mainstem North Fork from Boulder Creek to Kendal Creek and slough at RM 52	380	8
Maple Creek	416	12
Tributary 0411 and slough	322	8
Slough above Wick's Slough	311	7
Wick's Slough, slough below Wick's Slough, North Fork at Kendal Hatchery, Kendal Creek Slough, and Bear Creek	748	16
Bear Creek Slough	403	10
Mainstem North Fork from Kendal Creek to Mosquito Lake Road Bridge	551	10
Slough opposite Bell's Creek	68	3
Slough at natural gas pipeline crossing	150	5
Rutsatz Slough	551	21

$X^2 = 6.329$ df = 9 $P > 0.5$

Table 7. 1979-80 recovery rate by date of tagging.

Tagging dates	Number tagged	Number recovered
11/1 - 11/5/79	7	2
11/19	27	0
11/26 - 11/30	37	2
12/1	32	2
12/2	70	9
12/3	80	11
12/5	93	18
12/6	42	5
12/10	17	3
12/11	27	4

$X^2 = 12.56$ df = 9 $P > 0.1$

Table 8. 1979-80 recovery rate by location of tagging.

Location	Number tagged	Number recovered
First drift	5	1
Second drift	333	46
Fish Point, FWS	43	3
Fish Point Test Fishery	48	6
Horander Park	25	1

$X^2 = 4.011$ df = 4 $P > 0.1$

Table 9. 1979-80 recovery rate by fish length at tagging.

Length (cm)	Number tagged	Number recovered
55-69	115	7
70-74	106	11
75-79	107	15
80-84	84	13
85-94	43	10

$X^2 = 7.994$ df = 4 $P > 0.05$

Table 10. 1979-80 recovery rate by sex at tagging.

Sex	Number tagged	Number recovered
M	254	32
F	203	24

$X^2 = 0.050$ df = 1 $P > 0.5$

Table 11. 1979-80 tag ratio by date of recovery.

Date	Number examined	Number recovered
11/26 - 11/28/79	126	2
11/29 - 12/26	91	2
12/27 - 1/2/80	109	26
1/3 - 1/9	1585	29
1/10 - 1/16	989	11
1/11 - 1/23	183	1
1/24 - 1/25	293	0

$X^2 = 12.22$ df = 6 $P > 0.05$

Table 12. 1979-80 tag ratio by location of recovery.

Location	Recovered	Marked
Mainstem North Fork from Boulder Creek to Kendal Creek, slough at RM 52, side channel above Maple Creek, and Tributary 0411 and slough	52	2
Maple Creek	742	8
Wick's Slough	349	2
Kendal Creek and slough	851	13
Bear Creek and side channel	485	11
Mainstem North Fork from Kendal Creek to Mosquito Lake Road Bridge, Coal Creek	146	7
Johnny's Slough and slough below Racehorse Slough	287	5
Side channels 1 mi. above, and immediately above Mosquito Lake Road Bridge	644	11
Slough just above Mosquito Lake Road Bridge and slough opposite Bell's Creek	89	3
Side channel at natural gas pipeline crossing, Rutsatz Slough, and Irving's Slough	706	9

$X^2 = 14.513$ df = 9 $P > 0.1$

Table 13. Details from Table 5.

1978-79

Location	Total	Marked
1. Wick's Slough less part of Item 3	73[a]	0
2. Kendal Creek Slough	161	1
3. North Fork at Kendal Hatchery, Bear Creek, less item 4 , Wick's Slough less item 1, and Kendal Creek	154[b]	4
4. Bear Creek less part of Item 3	352	11
5. Bear Creek Slough	403[a]	10

1979-80

Location	Total	Marked
1. Wick's Slough	349[a]	2
2. Kendal Creek Slough	168	1
3. Kendal Creek	683	12
4. Bear Creek Slough, less part of Item 5	383[a]	9
5. Bear Creek and slough, less Item 4	102[b]	2

a. WDF index area.
b. Includes WDF index area.